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CHEMISTRY DIVISION - PHYSICAL AND INORGANIC SECTION

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PRELIMINARY REPORT ON VISCOSITY DETERMINATIONS ON A POTASSIUM-SODIUM ALLOY

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- Report P-2931 -

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ABSTRACT

An Ostwald type viscometer has been used to measure values of viscosity on a potassium-sodium alloy which was 43.4% potassium by weight. Viscosity of the alloy at 72°C was 1.267 relative to water at the same temperature. The values at higher temperatures were calculated from the volumes of alloy flowing per second at those temperatures, and the constant determined for the apparatus at 72°C.

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INTRODUCTION

A. Authorization

1. This project was authorized by BuShips Project Order No. 990/46 dated June 24, 1946.

B. Statement of Problem

2. The project covers the library and laboratory research necessary to arrive at satisfactory values for the physical properties of Sodium and Potassium alloys. The viscosity has been determined, on an alloy, for 43.4% K by weight. These values are the basis of this preliminary report.

C. Known Facts Bearing on the Problem

3. Absolute viscosities may be calculated from measurements made in a number of different types of apparatus. The type of apparatus to be used is determined to a great extent by the characteristics of the liquids under study. For the alloys which are particularly reactive with moisture and oxygen, completely closed viscometers are necessary. A preferred method of getting absolute viscosity; that is the falling-ball method with calculations based on Stoke's Law would be somewhat difficult at the high temperatures in an opaque viscometer. The more readily used method is a variation of the Ostwalt viscometer where the amount of alloy flowing in the capillary tube can be determined against time. At the same temperatures and under the same pressure head, measurements made on two fluids will give a viscosity measurement of one relative to the other. Water is customarily used as a reference fluid and then from the absolute viscosity of water, the absolute viscosity of the alloy at the same temperature can be calculated. This is the procedure which has been followed in the measurements tabulated at the end of the report. The relative viscosity has been calculated from the relation

$$\frac{n_1}{n_2} = \frac{d_1 t_1}{d_2 t_2}$$

where n_1 and n_2 are the viscosities of alloy and water respectively, d_1 and d_2 the densities, t_1 and t_2 the time required for equal volume of the fluids to flow. From the relative viscosity multiplied by the absolute viscosity of water at the same temperature, the absolute viscosity of the metals is determined at that temperature. This value of the viscosity with the relation $n = \frac{k}{v}$ gives a value for the constant k for the apparatus. n was the viscosity of the alloy and v the volume of alloy flowing in unit time. In this preliminary study the value of k was considered constant for the temperature range. This constant, with the volumes determined at temperature intervals, was

used to calculate the absolute viscosity over the temperature range given.

METHODS

A. Apparatus

4. An apparatus consisting of two horizontal tanks connected by a small capillary tube was constructed so that an upper tank (#1 on plate 1) and the coil of the capillary tube were enclosed in an electrically-heated furnace. The other tank was placed on the platform of the dial scales which gave continuous readings of the weight of that container. The bottom or #2 container was also connected to #1 container by 1/4" tubes through which the alloy could be forced from #2 to #1 container with the aid of moderate gas pressure. The 1/4 tubing was sealed off by a cold trap at the point shown as #3 on plate #1.

5. The capillary and return tubes were of such length and flexibility that weights of the order of 2 grams would cause a reflection on the dial scales. The dimensions of the capillary tube were 0.238 cm. inside diameter and 629 cm. in length.

6. The gas used in the viscosity studies was helium which had been purified by passing it over reduced copper at 450°C and then through reactivated charcoal at liquid nitrogen temperature.

B. Operation

7. From Plate 1, the operation of the unit was carried out as follows: The alloy was run through the valve #4 into container #2 until approximately 900 grams had entered the container. Valve #4 was then closed and helium pressure put on the #2 container through tube #5 which forced some gas back through the capillary tube, but at the same time exerted sufficient pressure on the alloy to cause it to flow through the cold trap (#4) into container #1. When #2 was nearly empty, as indicated by the scale reading, the pressure was released and the trap frozen in liquid nitrogen to form a seal against the return of the alloy by this route. The whole container and capillary tube were brought to desirable temperature and, with a pressure head adjusted to the desired value, the weight of the alloy which flowed through the capillary into container #2 was determined against time. The trap was then thawed and the operation repeated at various pressures and temperatures as desired.

RESULTS

8. Measurements were made on water at 72°C with the pressure head at 6.65 cm. of Hg. This gave 1.374 grams (1.407 cc) of water per

second. Measurements were then made on the alloy over the temperature range. At the same pressure head and from a curve of grams of alloy per second against temperature, 1.110 grams of alloy flowed per second. This gave 1.267 as a relative viscosity of the alloy at 72°C. This value multiplied by 0.3952, the absolute viscosity of water, gives 0.501 as the absolute viscosity of the alloy at 72°C. Then with the constant determined as mentioned in paragraph 3, the absolute viscosity was caluclated at several temperatures over the range from 65.5°C to 700°C. The value for k was calculated as 0.5611 and the results on the viscosity are given in Table 1 and plotted on Plate 2. Along with this curve, values for pure sodium and potassium are given. These values were those published by Y.S. Chiong, Proc. Roy. Soc. London A157, 264(1936).

TABLE 1

Temperature °C	Volume cc/sec	Viscosity centipoises ±10%
65.5	1.093	.514
100	1.178	.476
200	1.415	.397
300	1.645	.341
400	1.855	.303
500	2.046	.274
600	2.193	.256
650	2.223	.252
700	2.167	.259

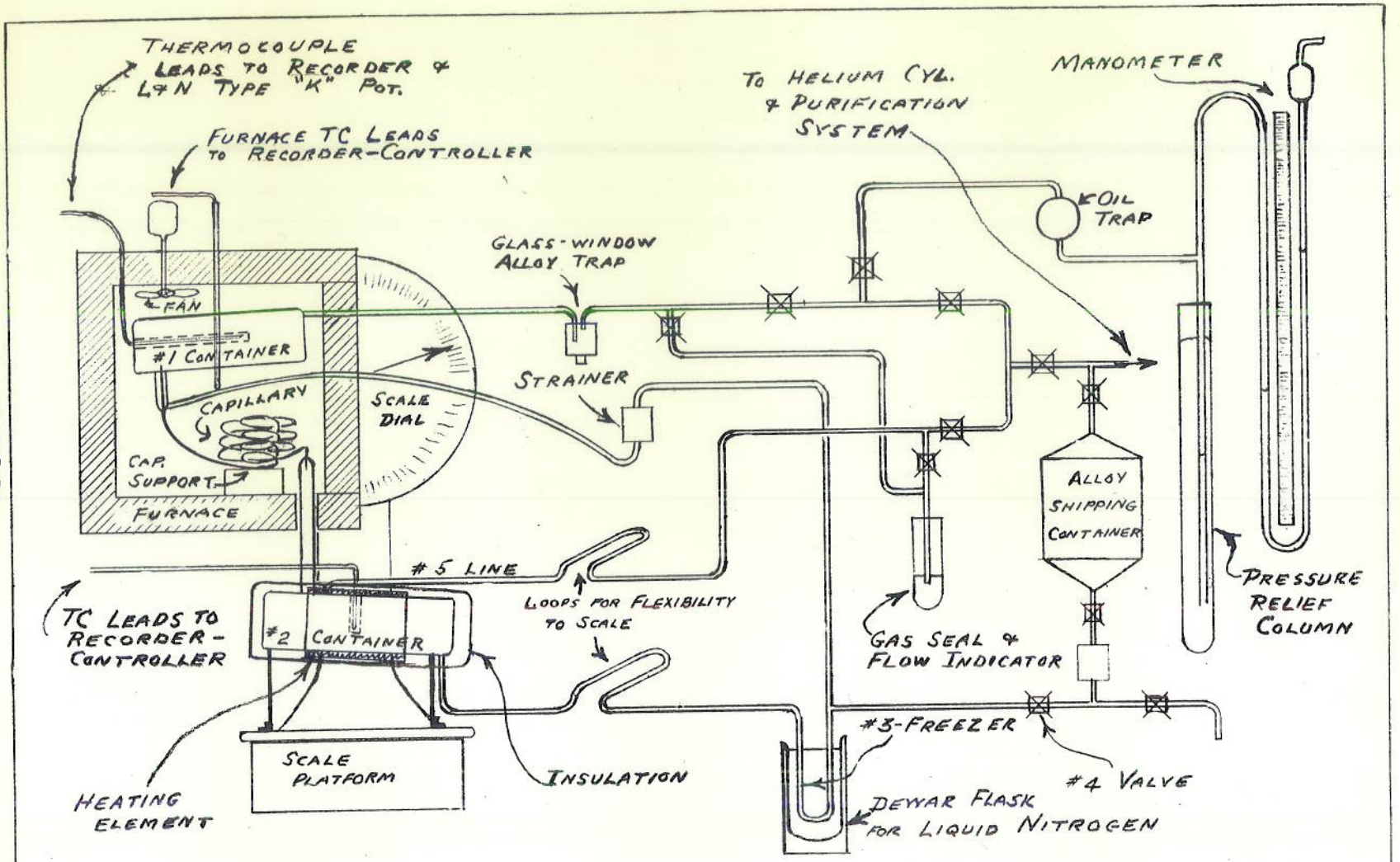

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PLATE-1

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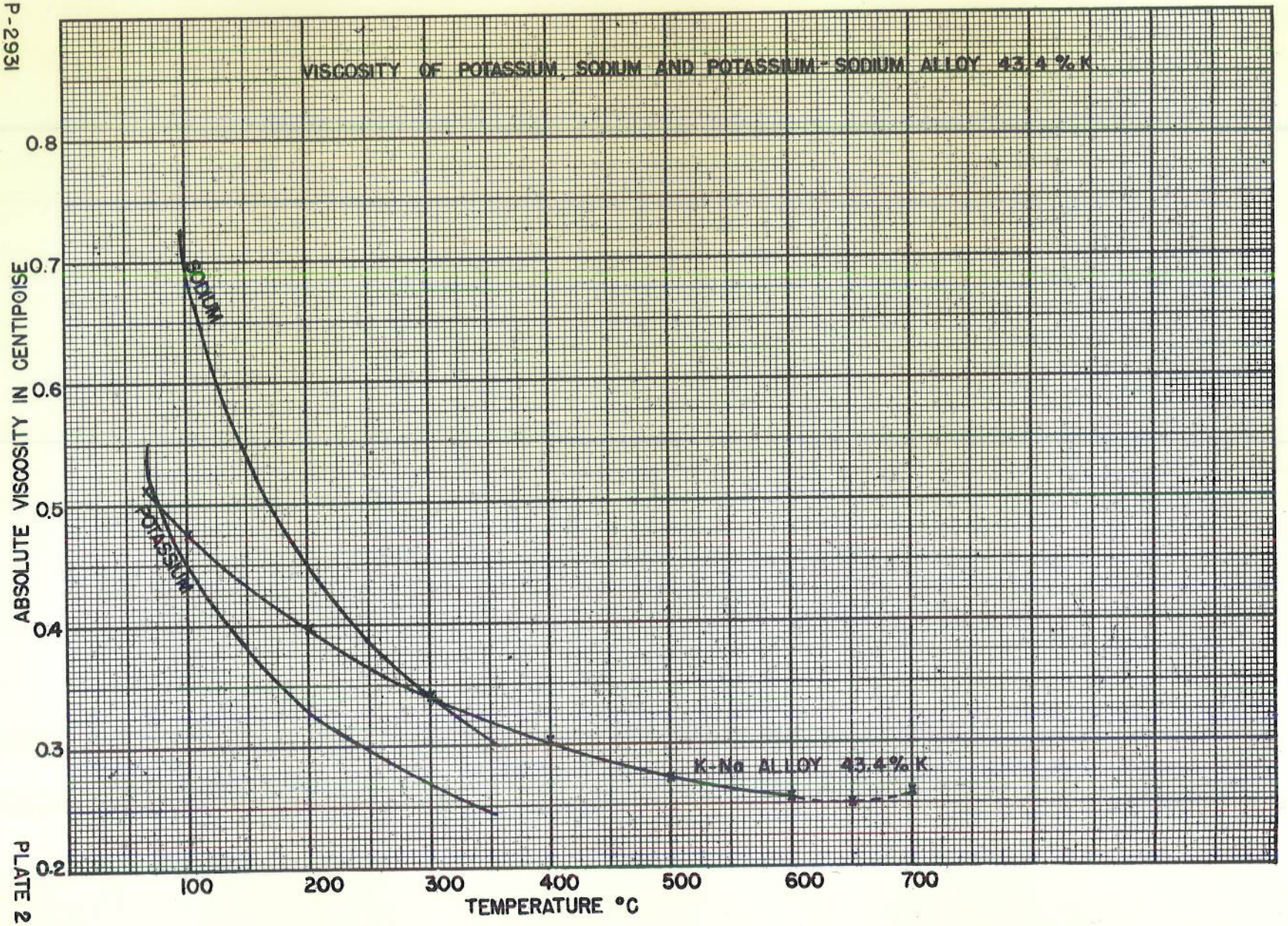

PLATE 2

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